Space Weather Technical Forecast

Issued on Monday, 22 July 2024 at 13:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares Likely. Chance of G1/Minor Storms Day 2 (23 July) but G3/Strong Storms Day 3 (24 July).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity was Moderate, with a peak flare of M3.9 observed at 22/0404UTC from AR3762 in the southeast. However, over the past 24 hours, there has been several M-class flares observed. An impulsive M1 flare was observed at 21/1630 UTC from a region very close to AR3757, simultaneously accompanied by a filament lift-off. The ejecta was soon followed by a full halo CME on coronagraph imagery and while no Stereo imagery is available, this CME has been analysed using C3/C2 LASCO imagery, with the results suggesting an Earth-directed CME may arrive either late day 2 (23 Jul) or more likely early day 3 (24 Jul).

There are currently twelve sunspots on the visible disc. The largest and most complex region remains AR3751, which consists of two delta spots, one within its leading portion and the second located within its intermediate portion. To its immediate east is AR3761, another relatively large region, which continues to show a spreading and increasingly open tendency though not magnetically complex. AR3744, which has been responsible for a number of M-class flares, is now on the western limb and is difficult to analyse. This region will be rotating off disc by the end of the day. AR3762 in the far east rapidly developed overnight, which has developed some complexity, with a delta spot emerging within its intermediate portion. This region is preceded by another region, which is currently unnumbered. A couple of new regions have emerged since previous analysis, with one large spot rotating onto the east limb, which is currently classified as an Hsx/Alpha. Another spot is emerging in the northeast, which looks to be a simple Bxo/Beta configuration at this stage.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE at L1, showed a continuation of a slow regime, with speeds ranging between 300 and 340km/s. Density was at below average. The IMF was weak, with the all-important north-south component, weakly negative (southwards) at -6nT by the end of the period. Phi angle was mostly positive (away from the Sun) with some brief re-orientation to negative (towards the Sun), perhaps indicating a probable SBC. Geomagnetic activity has been mostly Quiet (Kp1-2) throughout, although a more recent Unsettled interval (Kp 3) between 22/0600-0900UTC.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 remained at Background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was at Normal Background. The 24-hour fluence was well below Active, with 1e6 integrated pfu observed at 22/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is Likely throughout.

Solar Wind /Geomagnetic Activity: Two CMEs in the forecast. First one from 19 July arriving

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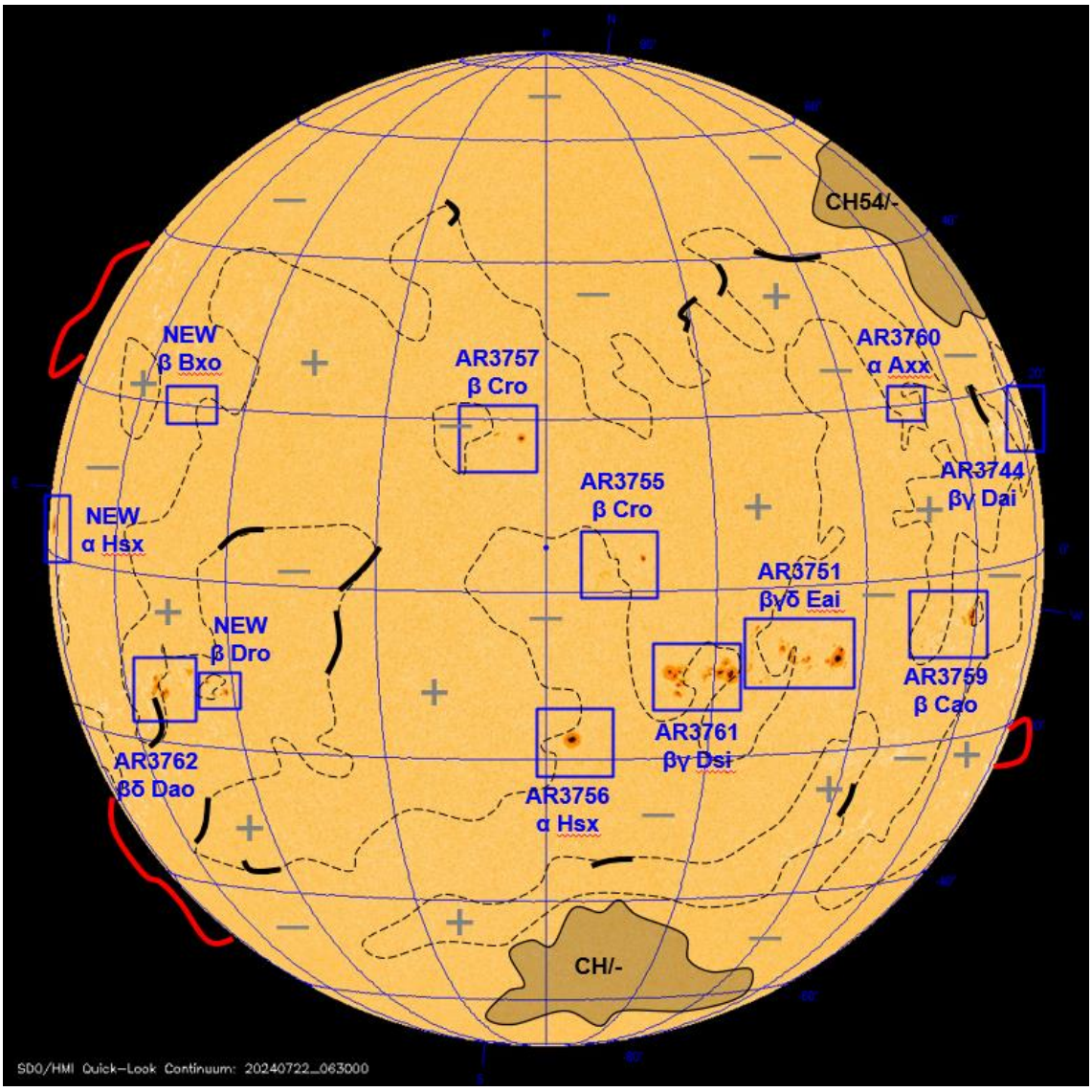
on Day 2 (23 July) with a chance of Chance of Minor Geomagnetic Storm (G1) and the second one from 21 July arriving either late Day 2 (23 July), but more likely to be early on Day 3 (24 July), with a chance of Strong Geomagnetic Storm (G3) conditions. Activity expected to gradually ease on Day 4 (25 July), with a slight Chance of Minor Geomagnetic Storm (G1).

Energetic Particles / Solar Radiation: High energy proton flux is most likely to remain at Background levels, but with a Slight Chance of rising above the S1/Minor Storm threshold in response to any notable flares from AR3744 or perhaps AR3751. High energy electron flux is expected to remain at Normal Background levels but may become Moderate or even High on Day 4 under CME influences. No Active fluence expected though.

Figure 1. Solar Analysis Valid 22/0630 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
There is an absence of significant coronal hole fast speed stream in the forecast, but there are potentially two Earth-directed CMEs.

First, the south-central filament eruption that left the Sun on Friday 19 July is due to arrive at Earth in the early UTC hours of Tuesday 23 July, bringing a Chance of Minor Geomagnetic Storm G1 conditions.

Secondly, a filament lift-off was observed at 21/1630 UTC. The ejecta was soon followed by a full halo CME on coronagraph imagery and while no Stereo imagery is available, this CME has been analysed using C3/C2 LASCO imagery, with the results suggesting an Earth-directed CME may arrive either late day 2 (23 Jul) or more likely early day 2 (24 Jul).

MOSWOC Enlil modelling and its associated ensemble places the first arrival fairly centrally within Day 2 (Tue, 23 July) and may become a stepping-stone for the second arrival, leading to denser and faster solar winds and a stronger geomagnetic response although any effects ought to be relatively well-contained to Day 3 (Wed, 24 July). The modelled solar wind speed is however considered to be a little fast, with observations currently near 300 km/s (rather than 400 km/s), which means the later ensemble members are likely to be more representative, with an arrival most likely at the beginning or in the early hours of 24 July.

Geomagnetic activity is expected to be mainly Quiet on Day 1 but increasingly stormy thereafter. First, a chance of Chance of Minor Geomagnetic Storm (G1) on Day 2 (23 July), followed by a chance of Strong Geomagnetic Storm (G3) conditions on Day 3 (24 July). Activity expected to gradually ease on Day 4 (25 July), with a slight Chance of Minor Geomagnetic Storm (G1).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	50	70	30
Strong	G3	No	1	2	30	5
Severe	G4	No	1	1	2	1
Extreme	G5	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/0400	Partial	Filament Eruption	S-Centre	615 km/s	23/0800 UTC +/- 9 hours	Northern portion of filament eruption, second of the two
21/1620	Full	Filament liftoff	NE quadrant	1050 km/s	24/0300 UTC +/- 9hrs	Low confidence

Figure 2: MOSWOC ENLIL, shows the arrival of two separate CMEs, the first one on the 23 July quickly followed by a more potent one early on the 24 July.

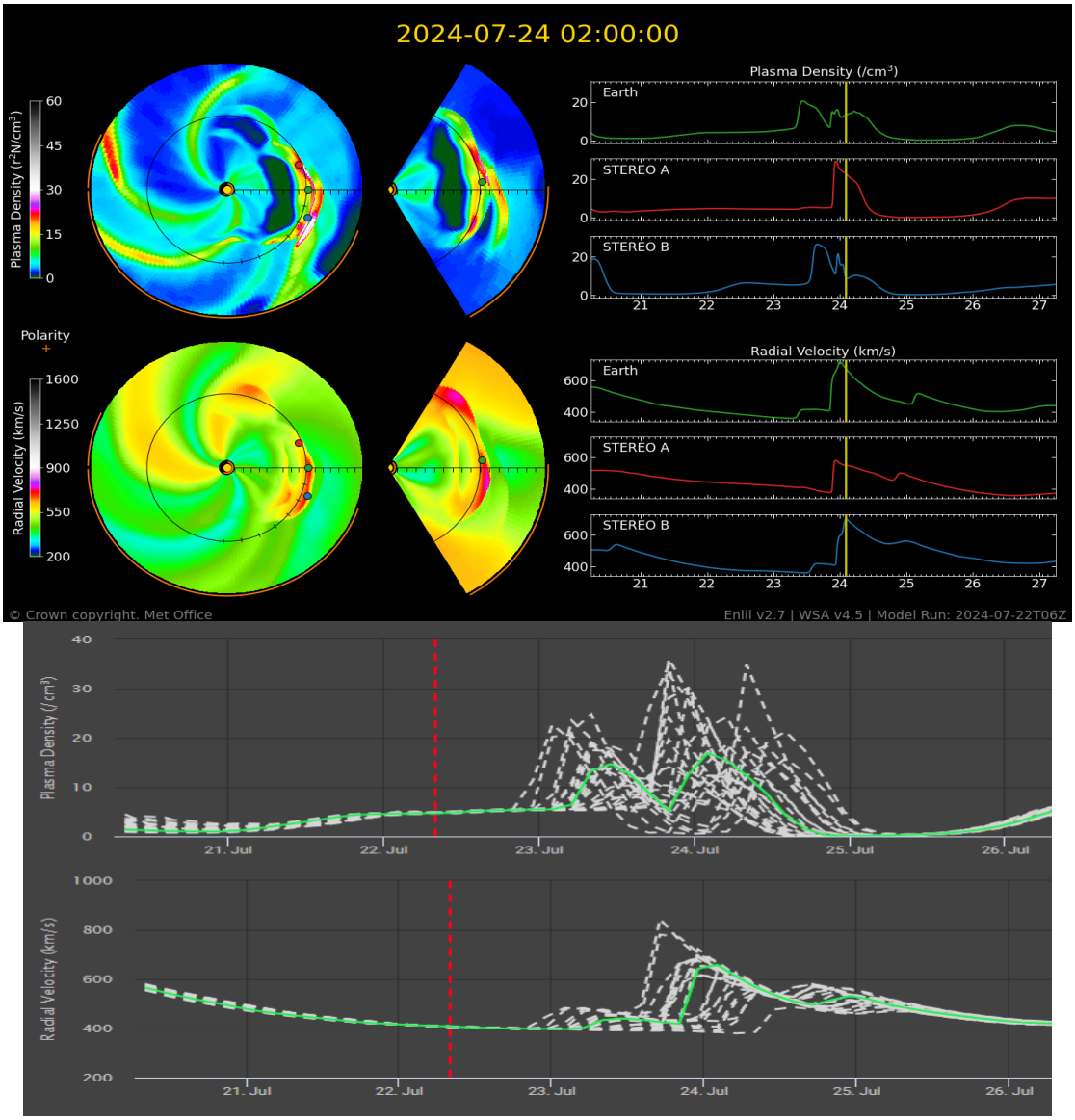

Figure 3: SDO-aia 304 showing a filament lifting off the sun around 21/1620 UTC (left) and Highly contrasted Coronagraph image from C2 showing the halo that followed the liftoff (right).

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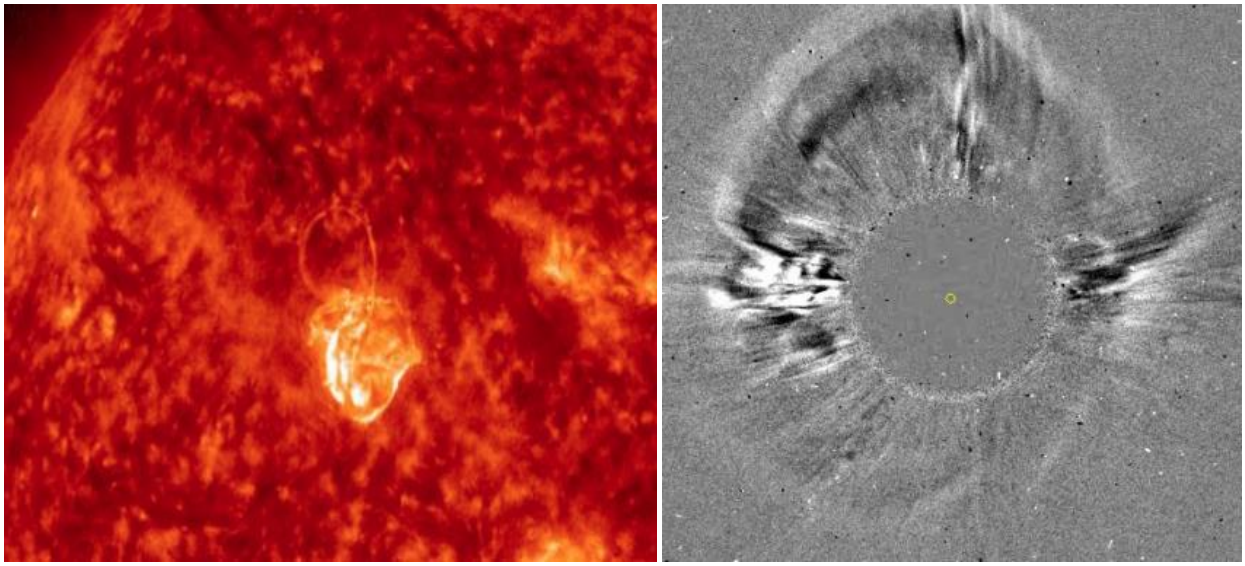

Radio Blackouts - X-Ray Flares:

With the possible exceptions of imminent arrival of Ex-AR3731 and Ex-AR3733 over the eastern solar horizon (possibly visible as flux looping in AIA171), the current cohort of front-sided regions should provide the peak population for the period, and a gradual decrease is otherwise expected over the four days. Most relevantly, the most active region of the past 36 hours or so, AR3744 in the northwest should depart the Earth-facing side on Day 2 (23 July), leading to a slight decrease in the risk of M-class flares.

On the other hand, the recent development of the easternmost regions, AR3762 and the new region preceding it, brings another risk of M-class flares, perhaps even greater than of late. Consequently, the probabilities have been kept the same for the next four days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 4: GOES-18 X-Ray flux trace.

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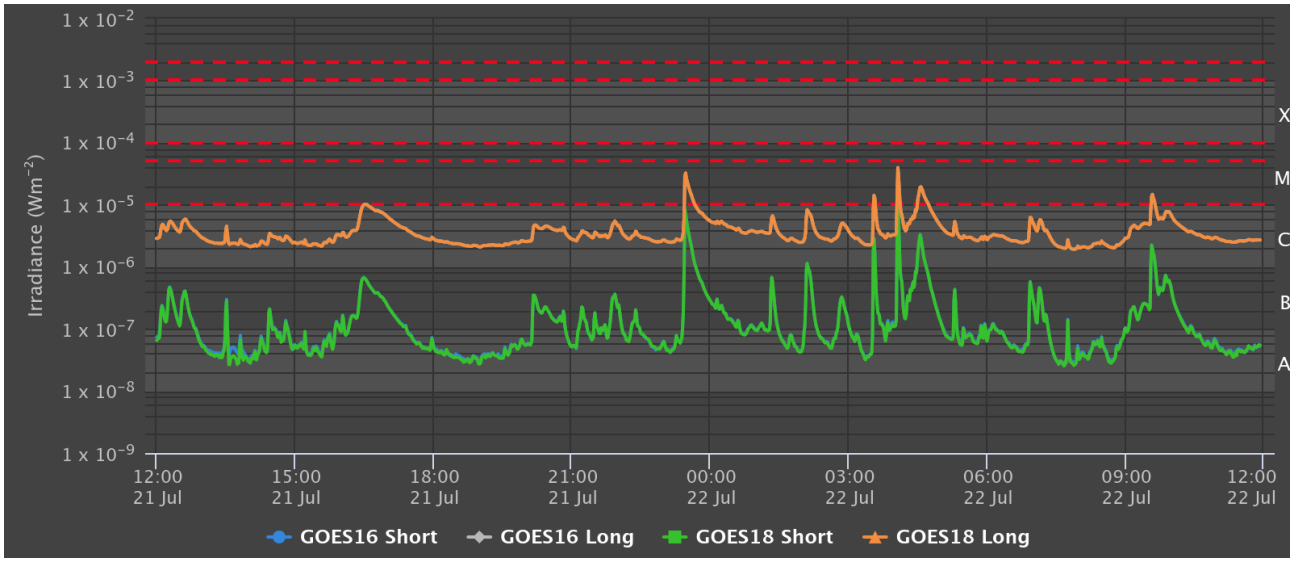

Solar Radiation Storms - (High Energy Protons):
GOES18 proton flux remains at Background levels, despite potentially generative flares from near the western limb emanating from AR3744 in the past 24 hours.

The probability of events breaching S1 increases very slightly over time as some of the more complex centre-disc regions move into the better-connected solar western hemisphere, where high energy protons have a greater likelihood of reaching Earth via the Parker Spiral. AR3744 itself should cross onto the far side by Day 2 (23 July), however it will retain some presence in terms of S1 risk for the remainder of the period, with its contribution decreasing as that from AR3751's increases.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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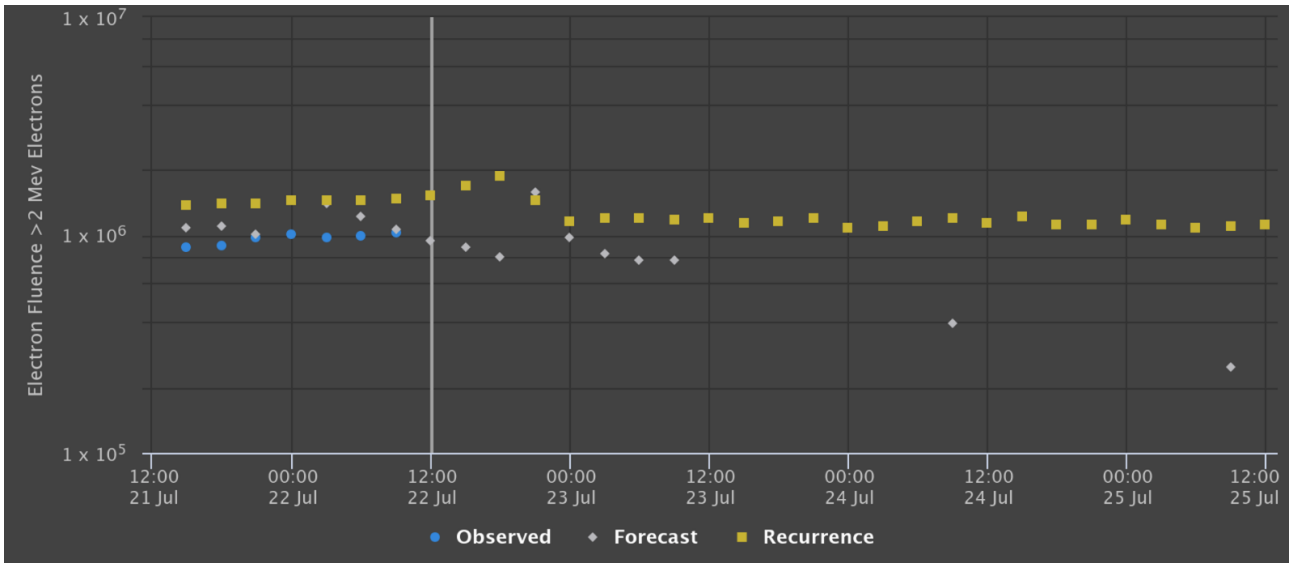
High Energy Electrons Event (≥ 2MeV):
The high energy electron flux as observed by GOES16 is currently at Normal Background and is expected to persist at this level initially given the lack of any notable sources of enhancement. The two CMEs that are expected to arrive (on Day 2 and Day 3) have the potential to significantly increase counts in the Van Allen belts, however this is unlikely to happen before Day 4 (25 July) since the peak of the geomagnetic activity is expected to take place on Day 3 (24 July).

The current high energy electron flux is also at such low level that any significant increase in fluence is most likely to occur outside of the forecast period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM electron fluence



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